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EVALUATION OF HAZARDOUS AND TOXIC WASTE MANAGEMENT BASED ON INPUT, PROCESS, AND OUTPUT ASPECTS AT ROYAL PRIMA GENERAL HOSPITAL MEDAN

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Abstrak

Limbah bahan berbahaya dan beracun (B3) yang dihasilkan oleh fasilitas pelayanan kesehatan hanya berkisar 10–20% dari total limbah, namun memiliki potensi risiko tinggi terhadap kesehatan manusia dan lingkungan apabila tidak dikelola sesuai standar. Penelitian ini bertujuan untuk mengevaluasi pengelolaan limbah B3 di Rumah Sakit Umum Royal Prima Medan tahun 2024 berdasarkan aspek input, proses, dan output. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan melibatkan enam informan yang dipilih secara purposive. Data dikumpulkan melalui wawancara mendalam, observasi langsung, dan studi dokumentasi, kemudian dianalisis menggunakan analisis konten kualitatif dengan dukungan triangulasi sumber, metode, dan waktu untuk menjamin keabsahan data. Hasil penelitian menunjukkan bahwa aspek input secara umum telah memadai, meliputi ketersediaan sumber daya manusia yang kompeten, sarana prasarana yang cukup, serta dukungan anggaran. Pada aspek proses, pengelolaan limbah telah dilaksanakan sesuai dengan standar operasional prosedur dengan tingkat kesesuaian mencapai 97,6%. Meskipun demikian, masih ditemukan beberapa permasalahan, antara lain ketidakkonsistenan dalam pemilahan limbah, keterbatasan kapasitas penyimpanan sementara pada unit dengan volume limbah tinggi, pelabelan kendaraan pengangkut yang belum lengkap, serta ketersediaan alat pelindung diri (APD) di area penyimpanan yang belum optimal. Temuan ini menunjukkan perlunya peningkatan pengawasan, optimalisasi sarana prasarana, serta penguatan kepatuhan terhadap standar operasional guna meningkatkan efektivitas dan keberlanjutan pengelolaan limbah B3 di fasilitas pelayanan kesehatan.

Kata Kunci: Pengelolaan Limbah Berbahaya; Pengelolaan Limbah Rumah Sakit; Kesehatan Lingkungan; Kepatuhan terhadap peraturan; Kerangka kerja masukan–proses–keluaran.

Abstract

Hazardous and toxic waste generated by healthcare facilities constitutes only about 10–20% of total waste but poses significant risks to human health and the environment if not properly managed. This study aimed to evaluate the management of hazardous and toxic waste at Royal Prima General Hospital, Medan, in 2024 based on input, process, and output aspects. This research employed a descriptive qualitative approach involving six informants selected through purposive sampling. Data were collected through in-depth interviews, direct observation, and document review, and were analyzed using qualitative content analysis supported by source, method, and time triangulation to ensure data validity. The findings indicate that the input aspect is generally adequate, including the availability of competent human resources, sufficient infrastructure, and financial support. The process aspect shows a high level of compliance with standard operating procedures, with an overall conformity rate of 97.6%. However, several critical issues were identified, including inconsistent waste segregation practices, limited temporary storage capacity in high-volume units, incomplete labeling of waste transport vehicles, and suboptimal availability of personal protective equipment in storage areas. These findings highlight the need for strengthened supervision, improved facility capacity, and stricter adherence to operational standards to enhance the effectiveness and sustainability of hazardous waste management in healthcare settings.

Keywords: Hazardous Waste Management, Hospital Waste Management, Environmental Health, Regulatory Compliance, Input–Process–Output Framework

INTRODUCTION

Hospitals are healthcare institutions that play a vital role in improving public health through comprehensive promotive, preventive, curative, and rehabilitative services (Sevilla, 2023; Made, 2022). Alongside these functions, hospitals generate various types of waste as a consequence of their operational activities, including medical waste that poses potential risks to human health and the environment (Novani, 2021). Globally, the World Health Organization estimates that approximately 80% of healthcare waste is non-hazardous, while the remaining 20% consists of hazardous waste that may be infectious, toxic, or radioactive (Haspiannoor, 2020). Although relatively small in proportion, hazardous waste requires strict and standardized management due to its significant risk potential.

In Indonesia, the management of hazardous and toxic waste (B3 waste) from healthcare facilities is regulated through Government Regulation No. 22 of 2021 on Environmental Protection and Management and Ministry of Environment and Forestry Regulation No. P.56 of 2015 concerning technical procedures for healthcare waste management. These regulations emphasize that waste management must be carried out comprehensively, covering stages from minimization, segregation, storage, transportation, to final treatment (Prasetiawan, 2020). Proper implementation of these standards is essential to prevent adverse impacts such as environmental contamination, occupational hazards, and nosocomial infections (Purwati, 2018).

However, previous studies indicate that gaps persist between regulatory standards and field implementation. Inconsistencies in waste management practices have been reported, including incomplete use of personal protective equipment and delays in waste transportation by third-party services (Firda, 2019). These findings suggest that compliance with regulations remains a challenge, particularly in developing countries where the number of healthcare facilities continues to increase. Despite existing guidelines, variations in infrastructure, human resources, and operational practices may influence the effectiveness of waste management systems.

At the local level, the increasing demand for healthcare services in urban areas such as Medan further underscores the urgency of effective waste management. Royal Prima General Hospital, as one of the private healthcare providers in Medan, represents an important setting to examine how hazardous and toxic waste management is implemented in practice. However, limited studies have specifically evaluated waste management systems in private hospitals using a comprehensive and systematic framework.

Unlike previous studies that primarily assessed hospital waste management from regulatory or operational perspectives, this study evaluates hazardous and toxic waste management through an integrated input–process–output framework. This approach enables a more holistic assessment by examining not only compliance outcomes but also the availability of resources and the quality of implementation processes (Rusyda, 2022). Therefore, this study aims to evaluate the management of hazardous and toxic waste at Royal Prima General Hospital in Medan in 2024 based on input, process, and output aspects, in order to determine the level of compliance with applicable standards and identify factors influencing its implementation.

The findings of this study are expected to provide evidence-based insights for improving waste management practices, strengthening regulatory compliance, and supporting policy development in healthcare waste management, particularly in similar hospital settings.

LITERATURE REVIEW

Hospitals are healthcare institutions that play a strategic role in improving public health through comprehensive promotive, preventive, curative, and rehabilitative services (Sevilla, 2023; Made, 2022). In performing these functions, hospitals inevitably generate various types of waste, including hazardous and toxic waste that poses risks to both human health and the environment (Novani, 2021; Sulfawandi, 2019). According to the World Health Organization, healthcare waste consists of general waste and hazardous waste requiring special handling, highlighting the importance of proper waste management within healthcare systems (Haspiannoor, 2020). Therefore, hospitals are not only responsible for delivering quality medical services but also for ensuring environmentally sound and safe waste management practices (Fauziah, 2020).

Hazardous and toxic waste refers to waste containing substances or energy that can harm the environment and living organisms due to its characteristics, concentration, or quantity (Rusyda, 2022; Salma, 2023). In Indonesia, the management of such waste is regulated under Government Regulation No. 22 of 2021 and Ministry of Environment and Forestry Regulation No. P.56 of 2015, which outline procedures from waste reduction to final disposal. These regulations aim to minimize the hazardous impacts of waste through systematic management (Ministry of Environment and Forestry of the Republic of Indonesia, 2020). Despite these comprehensive guidelines, challenges persist in implementation, including inadequate facilities, limited human resources, and inconsistent compliance with operational standards (Firda, 2019; Prasetiawan, 2020).

Hazardous and toxic waste is characterized by properties such as being explosive, flammable, reactive, infectious, corrosive, and toxic, making it highly dangerous if not properly managed (Sulfawandi, 2019). Types of medical waste within this category include infectious waste, sharps, pharmaceutical waste, chemical waste, and radioactive waste generated across various hospital units (Muchtar, 2019; Ummul, 2022). Improper handling of such waste can lead to serious health risks, including nosocomial infections, poisoning, and environmental contamination (Purwati, 2018; Fauziah, 2020; Rachmawati et al., 2018). Therefore, strict adherence to safety procedures is essential throughout all stages of waste management.

The management of hazardous and toxic waste involves several interconnected stages, including waste minimization, segregation, storage, transportation, treatment, and final disposal (Indonesian Ministry of Environment, 2020). Each stage must comply with standard operating procedures and be supported by adequate infrastructure and trained personnel (Prasetiawan, 2020; Ummul, 2022). The use of standardized color coding, symbols, and labeling systems is also essential to ensure safety and prevent errors in waste handling (Muchtar, 2019). In addition, occupational health and safety measures, such as the use of personal protective equipment and staff training, play a critical role in minimizing risks during waste management activities (Firda, 2019).

Evaluation of hazardous and toxic waste management is essential to assess the level of compliance between existing practices and regulatory standards (Hamdi, 2020; Magdalena, 2021). A comprehensive evaluation approach can be conducted using the input–process–output framework, which allows for a systematic assessment of resources, implementation processes, and outcomes (Rusyda, 2022). One method frequently applied is the use of scoring systems, such as Likert-scale-based assessments, to measure the degree of compliance with established standards (Ummul, 2022). The results of such evaluations are useful in identifying gaps and areas that require improvement to enhance waste management performance (Prasetiawan, 2020).

Effective management of hazardous and toxic waste requires strong policy support, adequate resources, and continuous monitoring and evaluation mechanisms (Indonesian Ministry of Environment, 2020). Collaboration with licensed third-party waste management services is also an important component to ensure compliance with regulatory standards (Firda, 2019). The integration of regulatory frameworks, operational practices, and evaluation systems will contribute to a sustainable waste management system. Therefore, studies evaluating hazardous waste management are essential to provide evidence-based recommendations and support the development of safer and more environmentally responsible healthcare services (Sevilla, 2023; Made, 2022; Fauziah, 2020).

RESEARCH METHODS

This study employed a descriptive qualitative approach to explore hazardous and toxic waste management practices at Royal Prima General Hospital, Medan. A qualitative approach was selected because it allows an in-depth understanding of operational practices, compliance processes, and implementation challenges within their real-world context (Hendryadi et al., 2019; Purba et al., 2021). The study was conducted at Royal Prima General Hospital, Medan, Indonesia, from March to May 2024. The hospital was selected because it is one of the major private healthcare providers in Medan and generates hazardous and toxic waste from various healthcare service activities.

The study involved six informants consisting of hospital administrators, heads of related units, and hazardous waste management staff. Informants were selected using purposive sampling based on their direct involvement in hazardous waste management activities. Inclusion criteria included having at least three years of work experience and active involvement in waste management operations or supervision. Data collection was continued until information saturation was achieved, indicated by the repetition of similar information across interviews. Data were collected through in-depth interviews, direct observation, and document review. Interviews were conducted using semi-structured interview guides focusing on input, process, and output aspects of hazardous waste management. Observations were carried out in waste segregation, storage, and transportation areas, while supporting documents such as standard operating procedures (SOPs), training records, and waste transportation logs were also reviewed.

Data were analyzed using qualitative content analysis. The analysis process included data reduction, data categorization, theme identification, data presentation, and conclusion drawing following the model proposed by Miles et al. (2018). Interview transcripts and observation notes were coded manually to identify recurring themes related to hazardous waste management practices. The compliance score was calculated using an observation checklist developed based on the Regulation of the Minister of Environment and Forestry No. P.56/MENLHK-SETJEN/2015 concerning procedures and technical requirements for hazardous waste management in healthcare facilities. Each indicator was scored "1" if fulfilled and "0" if not fulfilled. The total score was converted into percentages to determine compliance levels.

Credibility was ensured through source, method, and time triangulation, member checking, and prolonged engagement during field observations. Transferability was supported through detailed descriptions of the research setting and participants. Dependability was maintained by documenting interview transcripts, observation notes, and coding processes, while confirmability was strengthened through document review and peer discussion during data interpretation. This study obtained official permission from Royal Prima General Hospital, Medan. All informants voluntarily participated in the study and provided informed consent before interviews were conducted. Confidentiality and anonymity of participants were maintained throughout the research process.

RESULTS AND DISCUSSION

Results

Characteristics of Informants

This study involved six informants consisting of hospital administrators, department heads, and hazardous waste management staff. All informants had 4–7 years of work experience, were predominantly bachelor's degree holders, and aged between 43–48 years, indicating adequate experience and understanding of hazardous waste management practices.

Table 1. Thematic Findings of Hazardous Waste Management

Theme	Findings	Interview Evidence	Observation Evidence	Document Evidence
Human Resource Readiness	Staff are trained and understand SOPs	"All staff have participated in hazardous waste training."	Staff used PPE properly	Training records available

Infrastructure & Facilities	Facilities adequate but storage limited in some units	“Storage becomes full in ICU.”	Some overflow in peak hours	Facility checklist meets standards
Waste Segregation	Segregation implemented but inconsistent	“Mistakes occur when staff are rushed.”	Misplaced waste found	SOP available but not fully followed
Storage System	Storage meets standards (≤2x24 hours)	“Storage follows regulations.”	Proper labeling observed	Storage logs recorded
Transportation	Routine and safe transportation system	“Transported twice daily.”	PPE used, dedicated route applied	Transport schedule documented
Compliance Gaps	Minor issues still exist	“Vehicle labeling incomplete.”	PPE incomplete in some areas	Checklist shows minor gaps

Table 2. Compliance Score of Hazardous Waste Management

Component	Indicators Fulfilled	Total Indicators	Percentage	Category
Reduction & Segregation	32	33	97%	Compliant
Storage	24	25	98%	Compliant
Transportation	49	50	98%	Compliant
Total	105	108	97.6%	Highly Compliant

The compliance score was calculated using an observation checklist based on Minister of Environment and Forestry Regulation No. P.56/2015. Each fulfilled indicator was scored “1” and unfulfilled “0”, then converted into a percentage.

The results show that hazardous waste management at Royal Prima General Hospital is generally well implemented, with a high compliance rate of 97.6%. Human resources are competent and supported by regular training, while infrastructure and facilities are mostly adequate. Waste segregation is conducted at the source, and storage and transportation processes follow standard procedures. Waste segregation procedures are generally implemented according to SOPs, although mistakes occasionally occur during busy working hours. However, several operational challenges were identified, including inconsistent waste segregation, limited storage capacity in high-volume units, incomplete labeling of transport vehicles, and suboptimal PPE availability in certain areas. These findings indicate that although the system is formally compliant, there are gaps in day-to-day implementation. Temporary storage areas in high-volume units such as ICU sometimes become overloaded before scheduled transportation.

DISCUSSION

This study found that hazardous and toxic waste management at Royal Prima General Hospital Medan has generally been implemented in accordance with applicable regulatory standards. The overall compliance score reached 97.6%, indicating that most indicators related to reduction and segregation, storage, and transportation were fulfilled. From the input aspect, the hospital has competent human resources, regular training, adequate infrastructure, and financial support for waste management activities. From the process aspect, waste segregation is carried out at the source, temporary storage follows the required time limit, and transportation is conducted routinely using a dedicated route. However, the findings also show that high formal compliance does not eliminate operational weaknesses. Several issues remain, including inconsistent waste segregation during busy working hours, limited temporary storage capacity in high-volume units such as the ICU, incomplete labeling of waste transport vehicles, and suboptimal availability of personal protective equipment in several areas. Thus, the main finding of this study is the coexistence of strong regulatory compliance and practical implementation gaps.

The relationship between input, process, and output in this study shows that adequate resources do not automatically produce fully consistent implementation. The input–process–output framework used in this research helps explain why a hospital with trained personnel, available SOPs, and sufficient facilities may still experience operational gaps. In theory, as emphasized by Rusyda (2022), adequate input should support effective processes and produce compliant output. However, the findings indicate that the process stage is highly influenced by workload, staff discipline, supervision intensity, and the volume of waste generated in specific units. This explains why segregation errors still occur, especially when staff are rushed or when service intensity is high. Similarly, storage capacity that appears adequate at the institutional level may become insufficient in units with high waste production. Therefore, the problem is not merely the absence of resources, but the mismatch between standardized procedures and dynamic operational realities. This suggests that compliance must be understood as a continuous practice rather than a static administrative achievement.

These findings are consistent with previous studies that emphasize the importance of trained personnel, adequate facilities, and regulatory compliance in hazardous waste management. Salma (2023) argues that competent human resources are essential for effective hazardous waste handling, and this study supports that view because staff training contributed to the hospital's high compliance score. Rusyda (2022) also highlights the importance of infrastructure in minimizing environmental and occupational risks, which is reflected in the generally adequate storage and transportation system found in this study. However, this study also confirms Firda's (2019) finding that discrepancies often remain between regulatory standards and field implementation, particularly in the use of personal protective equipment and transportation procedures. The novelty of this study lies in showing that a very high compliance score can still conceal process-level weaknesses. Unlike studies that assess hospital waste management mainly through regulatory fulfillment, this research demonstrates that qualitative evaluation is needed to reveal hidden gaps in daily practice, especially in segregation behavior, storage capacity, vehicle labeling, and PPE readiness.

The meaning of these findings can be interpreted within the broader social, institutional, and ideological context of hospital responsibility. Socially, hospitals are not only institutions for healing patients but also organizations that may create environmental and occupational risks through their waste production. The finding that hazardous waste accounts for only a small proportion of total healthcare waste but carries high risk reinforces the idea that minor procedural errors may have serious consequences. Historically, waste management in healthcare facilities has often been treated as a technical matter, while this study shows that it is also a matter of organizational culture and institutional accountability. Ideologically, compliance with Government Regulation No. 22 of 2021 and Ministry of Environment and Forestry Regulation No. P.56/2015 reflects the hospital's commitment to environmental protection, public health, and worker safety. However, the remaining gaps indicate that regulatory compliance must be internalized as an ethical commitment, not only as an administrative requirement. In this sense, hazardous waste management becomes a measure of institutional responsibility toward humans and the environment.

The implications of these findings have both functional and dysfunctional dimensions. Functionally, the high compliance score indicates that the hospital already has a strong foundation for safe and sustainable hazardous waste management. The availability of SOPs, training records, storage logs, and transportation schedules shows that the hospital has developed an organized management system. This contributes to reducing the risk of infection, occupational exposure, environmental contamination, and regulatory violations. However, the dysfunctional implication appears when high compliance creates a false sense of security. If the hospital relies only on numerical indicators, small but recurring problems may be overlooked. Inconsistent segregation, incomplete labeling, limited storage capacity, and insufficient PPE may gradually weaken the effectiveness of the entire system. These issues show that compliance without consistent supervision may become procedural rather than substantive. Therefore, the reflection from this study is that hospitals should not treat compliance scores as final outcomes, but as diagnostic tools for identifying which aspects of practice still require improvement and continuous monitoring.

Based on these findings, several policy and managerial actions are needed to improve hazardous waste management at Royal Prima General Hospital Medan. First, the hospital should strengthen routine supervision at the unit level, especially in high-volume areas such as the ICU, emergency unit, laboratory, and operating room. Second, refresher training should be conducted periodically, not only to improve knowledge but also to build discipline and consistent behavior in waste segregation. Third, temporary storage capacity should be adjusted to the actual volume of waste generated by each unit, so that overload does not occur before scheduled transportation. Fourth, the hospital must ensure that all waste transport vehicles are properly labeled according to regulatory standards. Fifth, PPE availability should be audited regularly, particularly in storage and transportation areas. Finally, the hospital should develop an internal monitoring dashboard that combines checklist scores, incident reports, supervision notes, and waste volume data. Through these actions, hazardous waste management can move beyond formal compliance toward a more adaptive, preventive, and sustainable system.

CONCLUSION

This study demonstrates that hazardous and toxic waste management at Royal Prima General Hospital in Medan has achieved a high level of regulatory compliance (97.6%), supported by adequate human resources, infrastructure, and budget allocation. The implementation of waste management processes—covering segregation, storage, and transportation—generally follows established standard operating procedures. However, these findings should be interpreted cautiously. Despite the high compliance score, several operational gaps remain, including inconsistent waste segregation, limited storage capacity in high-volume units, incomplete labeling of transport vehicles, and suboptimal availability of personal protective equipment in certain areas. This indicates that formal compliance does not always reflect consistency in day-to-day practice.

This study contributes to the literature by applying an input–process–output evaluation framework to assess hazardous waste management in a hospital setting. The findings highlight that while input and process components may meet regulatory standards, implementation challenges can still affect overall system performance. Thus, compliance assessment should be complemented with qualitative evaluation to capture operational realities. From a practical perspective, the findings suggest the need for strengthened supervision, improved infrastructure capacity, and reinforcement of staff discipline to ensure more consistent implementation of waste management procedures. Continuous monitoring and periodic evaluation are essential to maintain and enhance system effectiveness.

This study has several limitations. First, the findings were derived from a single hospital setting with a limited number of informants, which may limit the transferability of the results to other healthcare institutions with different organizational structures and operational capacities. Second, this study did not include detailed quantitative data regarding budget allocation and waste generation volume. Third, operational practices may vary over time depending on workload, staffing conditions, and policy implementation. Therefore, future studies are recommended to involve multiple hospitals and employ mixed-method approaches to provide a broader understanding of hazardous waste management practices. Future research is recommended to incorporate mixed-method approaches, include multiple healthcare facilities, and examine additional variables such as organizational culture, workload, and supervision systems to provide a more comprehensive understanding of hazardous waste management practices.

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